Washington State Department of Transportation

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TOLL COLLECTION TECHNOLOGY: IS IT TIME FOR A CHANGE?

DRAFT REPORT FOR DISCUSSION

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1. INTRODUCTION

The Washington State Department of Transportation (WSDOT), Puget Sound Regional Council (PSRC), and King County have entered into an Urban Partnership Agreement (UPA) with the US Department of Transportation (US DOT). The UPA is a cooperative agreement to employ innovative transportation strategies that will improve traffic flow along SR 520 and I-90 between Seattle and the Eastside. One element of this program is to charge tolls to better manage traffic and raise revenues to pay for the reconstruction of the SR 520.

In the context of currently operating toll facilities of the Tacoma Narrows Bridge and SR 167, the implementation of tolling on SR 520 requires an examination of current toll collection technology choices for a number of reasons:

- High Volume: SR 520 is one of the two major bridges that cross Lake Washington connecting Seattle and the eastside suburbs. The current daily crossings of Lake Washington are approximately 110,000 vehicles per day.

- Need for Non-Stop Tolling: Tolls on SR 520 were previously collected manually by a small toll plaza on the eastern shore of Lake Washington. Each vehicle was required to stop and pay the toll. Today, if vehicles were required to stop to pay tolls, the resulting congestion would negate the benefit of improving the facility. Electronic tolling has eliminated the need for toll booths and enables non-stop, cashless toll collection. Unlike Tacoma Narrows Bridge (TNB), there will not be a cash lane option.

- Strategic Transportation Connection: Because SR 520 is a strategic link of the regional freeway system, more than just daily commuters will use the bridge, and without a cash payment option most users are likely to become established customers. There are approximately 3 million registered vehicles in King, Pierce and Snohomish counties with 1.7 million in King County alone. While not every vehicle will be equipped with a transponder and not every vehicle in the region will use the bridge, an anticipated demand for up to approximately 2 million transponders over 20 years is not unrealistic. The average number of vehicles available per household in King County is 1.71 (2000 US Census). Dividing this average vehicle ownership by 2 million transponders would imply that the number of customer accounts could easily approach 1 million over the next twenty years.

- Tolling on I-90: Tolling the I-90 floating bridge that parallels the SR 520 bridge to the south is also under consideration. If authorized, this would add approximately 150,000 tolling transactions per day and further increase the demand for customer accounts.

2. TOLLING BASED ON VEHICLE OCCUPANCY

Tolling will begin on SR 520 during 2010 before the new bridge is built with an expected two general purpose lanes and one HOV lane. The new bridge with the HOV3+ lane will be open to traffic in 2016 and all vehicles crossing SR 520 will be required to pay. However, the UPA includes a requirement to consider preferential pricing for HOV3+ vehicles.. Therefore, the current intent is to charge all vehicles, but to provide a discounted rate for HOVs. The requirement to toll vehicles based on the number of occupants is another reason to examine current toll collection technology.

There are five potential models for tolling based on vehicle occupancy:

1. Transponders for SOVs Only: Like SR 167, only vehicles paying to use the HOT lane are required to have a transponder. HOVs are not charged.

2. Transponders for SOVs with SOV/HOV Declaration Lanes: Only vehicles paying to use the HOT lane are required to have a transponder. At tolling points, drivers are required to choose a lane to declare as a HOV or SOV. HOVs are not charged

3. Transponders for All with SOV/HOV Declaration Lanes: On California's SR 91 Express Lanes, all vehicles are required to pay and must have a transponder. But at tolling points, drivers are required to choose a lane as a HOV or an SOV. HOVs receive a discount. Vehicles without transponders are considered to be violators.

4. SOV/HOV Declaration Transponder: All vehicles are equipped with transponders that allow a driver to push a button to declare the number of persons in the vehicle. The vehicle is then charged based upon the transponder setting.

5. HOV License Plate Registration: Requires HOV drivers to register as a carpool and provide information on their license plate and vehicle characteristics. Only registered HOVs can receive a discount. All other vehicles must have a transponder or are considered a violator. If a registered HOV cannot meet the vehicle occupancy requirements on a given day, they are required to pay the toll.

The characteristics of each approach are summarized in the following table.

Approach	Declaration Method	Enforcement	Considerations
1. Transponders for SOVs Only (WA SR 167, MnPass, San Diego I-15)	• SOV: Operational transponder • HOV: No transponder or shield/remove transponder	• Visual confirmation of number of occupants and presence of transponder in mixed traffic • Check for last transponder read using handheld device	• Hand held readers are not completely effective for roadside use • Does not enable automated enforcement
2. Transponders for SOVs with SOV/HOV Declaration Lanes	• SOV: Operational transponder in SOV lane • HOV: No transponder or shield/remove transponder in HOV lane	• Visual confirmation of number of occupants and presence of transponder in split traffic • Check for last transponder read using handheld device	• Requires right of way for declaration lanes at tolling point • Hand held readers are not completely effective for roadside use • Does not enable automated enforcement

Approach	Declaration Method	Enforcement	Considerations
3. Transponders for All with SOV/HOV Declaration Lanes (CA SR 91)	• All vehicles have transponders • Separate lanes for HOV and SOV at tolling point	• Vehicles without transponders are violators • Visual confirmation of number of occupants and presence of transponder in split traffic	• Requires right of way for declaration lanes at tolling point • Provides automated enforcement • Requires all user to obtain tags
4. SOV/HOV Declaration Transponder	• All vehicles have transponders	• Vehicles without transponders are violators • Visual confirmation of number of occupants and presence of transponder in split traffic	• Fits within existing right of way • Provides automated enforcement • Requires all user to obtain tags
5. HOV License Plate Registration (95 Express in Miami-Dade County)	• SOV: Operational transponder • HOV: Must register license plate	• Vehicles without transponders or registered carpools are violators. • Visual confirmation of number of occupants	• Fits within existing right of way • Provides limited form of automated enforcement • Requires certification of HOV status generally by third party

Starting with Option 5, this approach requires the registration, certification, and periodic validation of carpools and could be used with declaration lanes. The 95 Express project in Miami-Dade County will be one of the first to attempt this approach for HOV3+ only. They have established a formal registration process which is being performed by the Florida Commuter Services (SFCS) for each vehicle seeking an exception to the toll. There is the potential for a significant administrative burden associated with the registration, certification, and validation process. The approach requires registered carpools to pay if they do not meet the vehicle occupancy requirements on any given day. This reliance on HOVs to self pay will be harder to enforcement in the field and the incentive for fraud will be higher. Transponders provide a more reliable means to uniquely identify a vehicle. This approach is not recommended.

None of the facilities (SR 167, I-405, and I-90) that would likely convert from HOV lanes to HOT lanes and would charge HOVs a different rate have adequate right of way to provide up to three separate lanes for SOV/HOV declaration. The existing SR 520 bridge does not have adequate space but the new bridge's two general purpose plus one HOV lane would provide an opportunity in 2014. Given the general lack of adequate right of way on most anticipated facilities, options 2 and 3 are problematic. Option 1 may be adequate for lower volume facilities, but the does not provide the positive identification of each vehicle using the facility and does not allow for automated enforcement.

Option 4 - SOV/HOV Declaration Transponder provides the next best model after the declaration lanes in that the vehicle is uniquely identified and the driver must declare the vehicle occupancy

status for every trip. Those vehicles with out transponders are violators and would be automatically issued an invoice or a citation depending on the business rules for the facility. Field access to real time read data would enhance enforcement efforts. In addition, almost everyone using SR 520 will be required to pay a toll and, accordingly, most will acquire a transponder. The anticipated number of customers for SR 520 before and after the new bridge is complete is significant which will result in a significant increase in the number of vehicles equipped with transponders already. Option 4 is recommended.

3. TRANSPONDER REQUIREMENTS

The transponder selected for SR 520 will set the stage for electronic toll collection technology in Washington State for the next 10 to 15 years given the anticipated expansion of tolling. Potential transponders should be assessed against the following set of key requirements.

- Open Road Tolling (ORT): Can the transponder be used to accurately identify vehicles for cashless tolling during periods of congestion and at full highway speeds?
- Operational: Has the transponder been proven in an ORT application?
- Security: Are security features adequate to protect transaction and customer information?.
- Read/Write Capabilities: Is the ability to read the unique identification number and write information to the transponder provided?
- HOV Self Declare Capability: Can customers enter in the number of persons in the vehicle and provide confirmation of their declaration?
- Enforcement: Does the transponder support toll enforcement activities?
- Multiple Suppliers: Is the transponder available from more than one supplier?
- Ease of Migration: How difficult will it be to migrate from the use of Super eGo and TDMA transponders to the selected transponder?
- Vehicle Infrastructure Initiative (VII): Will the transponder provide a migration path to more advanced applications under the Federal VII program?
- Life Cycle Cost: What is the life cycle cost of the selected transponder?

As noted above, a national standard for transponders and their related DSRC protocol has not been established. Transponders are available in multiple protocols as illustrated in the following table. Only offerings relevant to WSDOT are listed. Note that all of the transponders listed below operate in the 915 MHz radio frequency band except for the emerging 5.9 GHz transponder.

Protocol	Primary Application	Geographic Range	Application in Washington State	Notes
5.9 GHz	1. Enhanced roadside to vehicle and vehicle to vehicle communication 2. Enables Vehicle Infrastructure Initiative (VII)	1. Emerging national standard 2. Demonstrations underway at Colorado E-470, Detroit, California, New York State Thruway, New York City	1. None	• Open DSRC protocol • Independent certification process expected next year • Multiple venders
Interagency Group (IAG) under E-ZPass program	1. Electronic Toll Collection	1. More than 16 million transponders for 23 agencies in 12 eastern states.	1. None	• Proprietary DSRC protocol • Read/Write capabilities • Manufactured by Mark IV
Super eGo™ sticker tag	1. Electronic Toll Collection 2. US Department of Homeland Security Free and Secure Trade (FAST) Program for cargo movements	1. Puerto Rico, Texas, Washington, Georgia, Florida 2. Land border crossings with Canada and Mexico	1. Tacoma Narrows Bridge 2. Blaine, WA Truck Crossing	• Proprietary DSRC protocol • Read/Write capabilities • Sticker tag • Manufactured by TransCore
Time Division Multiple Access (TDMA)	1. Commercial Vehicle Information Systems and Networks (CVISN) for weigh station bypass. 2. Toll Collection	1. United States and Canada under Norpass and PrePass programs 2. MnPass HOT Lane Project and 407 (Toronto) and as secondary protocol in Washington	1. Weigh station bypass under WSDOT CVISN program 2. Secondary protocol in Washington	• Open DSRC protocol • Read/Write capabilities • Multiple providers
Title 21	1. Electronic Toll Collection	1. California, Colorado	1. None	• Open DSRC protocol • Read only • Manufactured by TransCore and Sirit

4. WHY LOOK AT TOLL COLLECTION TECHNOLOGY NOW?

In 2003, WSDOT reviewed toll collection technology choices for the Tacoma Narrows Bridge (TNB) and reached the following decisions:

- To deploy Super e-Go™ sticker transponders as the primary AVI technology for electronic toll collection.

- To install dual function readers at TNB to accept for toll payment the current transponder on commercial vehicles participating in the electronic weigh station bypass program. (This transponder uses the Time Division Multiple Access (TDMA) protocol.)

- To develop and implement a migration plan for the new U.S. standard 5.9 GHz transponder so that multiple vendors can supply a standard toll transponder to the state in the future.

Since the implementation of the WSDOT Good To Go! electronic toll collection program, more than 100,000 accounts have been established with almost 250,000 associated transponders. The current program serves toll customers on TNB and the SR 167 High Occupancy Toll (HOT) Lane Pilot project.

5. REQUEST FOR INFORMATION

With these considerations in mind, WSDOT issued a Request for Information (RFI) in July 2008 seeking information on available and pending toll collection technologies. The key findings from vendor supplied information are summarized below:

- WSDOT received a total of 11 responses to the RFI from transportation tolling integrators, manufacturers, and vendors.

- The review of the responses confirmed that the current state of the art for non-stop, cashless electronic toll collection involves the use of two technologies to uniquely identify vehicles as they pass a tolling point. The first would install radio frequency transponders in vehicles which would provide automatic vehicle identification (AVI) information in the same manner that TNB electronic tolling works. The second technology captures license plate images of all vehicles not equipped with transponders. The license plate information is used to determine the registered owner of the vehicle, who would pay based on the license plate image. The customers without transponders could pay in advance or be issued an invoice for the toll. This second technology is commonly referred to as “video tolling”.

- The transponder is a two-way radio with a microprocessor, operating in the 915 MHz radio frequency band (within the United States) using dedicated short-range communication (DSRC) protocols. There are multiple DSRC protocols within the 915 MHz band. There is no national standard for DSRC protocols at this time. Several years ago, the 5.9 GHz band was set aside for the development of a national, interoperable DSRC protocol. The first 5.9 GHz transponders are about to enter the market. Test deployments are underway at several locations and the national certification program will be in place next year. However, the 5.9 GHz protocol has not yet been designated as the national protocol by the U S Department of Transportation.

- In an effort to enable HOV discount programs, multiple transponder manufactures are offering transponders that allow the toll customers to press a button or flip a switch on the transponder to declare how many persons are in the vehicle. This is in contrast to providing separate declaration lanes at tolling points for HOVs and SOVs. The lack of sufficient right-of-way to expand the roadway at tolling points makes this second option

difficult in the Puget Sound region. SR 167 HOT lanes is a point in case and similar constraints exist for I-405. Transponders with HOV self declare capability must have a hard case form factor because of the need to press a button or flip a switch.

- In looking towards the future of tolling practices, global positioning system (GPS)-based approaches are a new and emerging technology application. These applications for toll collection that include multi-purpose, vehicle-integrated GPS systems for tolling, assessment of Vehicle Miles Traveled (VMT), and vehicular safety systems. The GPS based systems show potential for supporting a broader regional pricing system. However, concerns remain in regards to:

  – GPS accuracy for lane discrimination in an urban environment – Vendors acknowledged it would be difficult for their systems to determine whether the vehicle was in an HOV or general purpose lane.

  – On Board Unit cost differential – A GPS-based system will only be cost effective for an area with many tolling points, such as a cordon-pricing application.

  – Customer service – The GPS-based on-board device vendors are not offering to provide customer services. Vendors would turn to third parties to provide this customer service function. This is not a proven model in the toll industry, and it is unknown how much interest these providers have in such a model.

  – Enforcement: Roadside enforcement units (mounted on gantries) or mobile "spot-checkers" using the video capture of license plate images would be needed for enforcement, adding another layer of infrastructure and service needs.

- A second emerging trend for toll collection is the use of third parties that pay tolls for their customers. Several firms offer a service to rental car companies to pay tolls for their customers. These third parties negotiate an arrangement with the local toll facility and charge the vehicle renters for the service. Video capture of license plates is used to identify the rental vehicles participating in the program. Under these arrangements, the toll is paid and the tolling agency avoids the need to track down individual renters.

In conclusion, the review of available and anticipated toll collection technology indicates that use of radio frequency deification (RFID) transponders supplemented by the video capture of license plate images remains the practical technology solution for the cashless, non-stop toll collection. In addition, the acceptance of payments from third parties should be considered for future tolling systems.

6. TRANSPONDER COMPARISON

With this introduction, the next table compares each the transponders by protocol with the requirements listed above.

Requirements	5.9 GHz	IAG	Super eGo™	TDMA	Title 21
Open Road Tolling (ORT	Best	Acceptable	Acceptable	Better	Acceptable
Operational	Testing	Yes	Yes	Yes	Yes

Requirements	5.9 GHz	IAG	Super eGo™	TDMA	Title 21
Security	Better	Acceptable	Acceptable	Acceptable	Acceptable
Read/Write Capabilities	Yes	Yes	Yes	Yes	No
HOV Self Declare Capability	Yes	Yes	Yes	Maybe	Yes
Enforcement	Better	Acceptable	Acceptable	Acceptable	Limited
Multiple Suppliers	Intent	Maybe	No	Possible	Possible
Ease of Migration	Requires installation of new readers	Supported by current readers	Current Technology	Current Technology	Supported by current readers
Supports VII	Yes	No	No	No	No
Form Factor	Hard Case	Hard Case	Sticker Tag (Available In Hard Case)	Hard Case	Hard Case (Available In Sticker Tag)
Notional Costs for Transponder	Under $100	$20-25	$10	$20-25	$20-25

The table reveals that each transponder has advantages and disadvantages. The 5.9 GHz transponder offers better performance, a path to advanced traffic management and safety applications as part of the VII program, an open protocol, and the promise of multiple vendors, but at a higher cost per unit. IAG is the regional standard for many toll facilities in the eastern part of the United States. Super eGo™ is operational in Washington State and will be available in a form factor that allows drivers to declare their HOV status, but does not offer a path to the future. TDMA is supported by the current reader base, provides better ORT capabilities, has proven enforcement capabilities, and is operational on the HOT lanes in Minneapolis. Title 21 is the standard in California but does not have read-write capabilities which limit its support of enforcement.

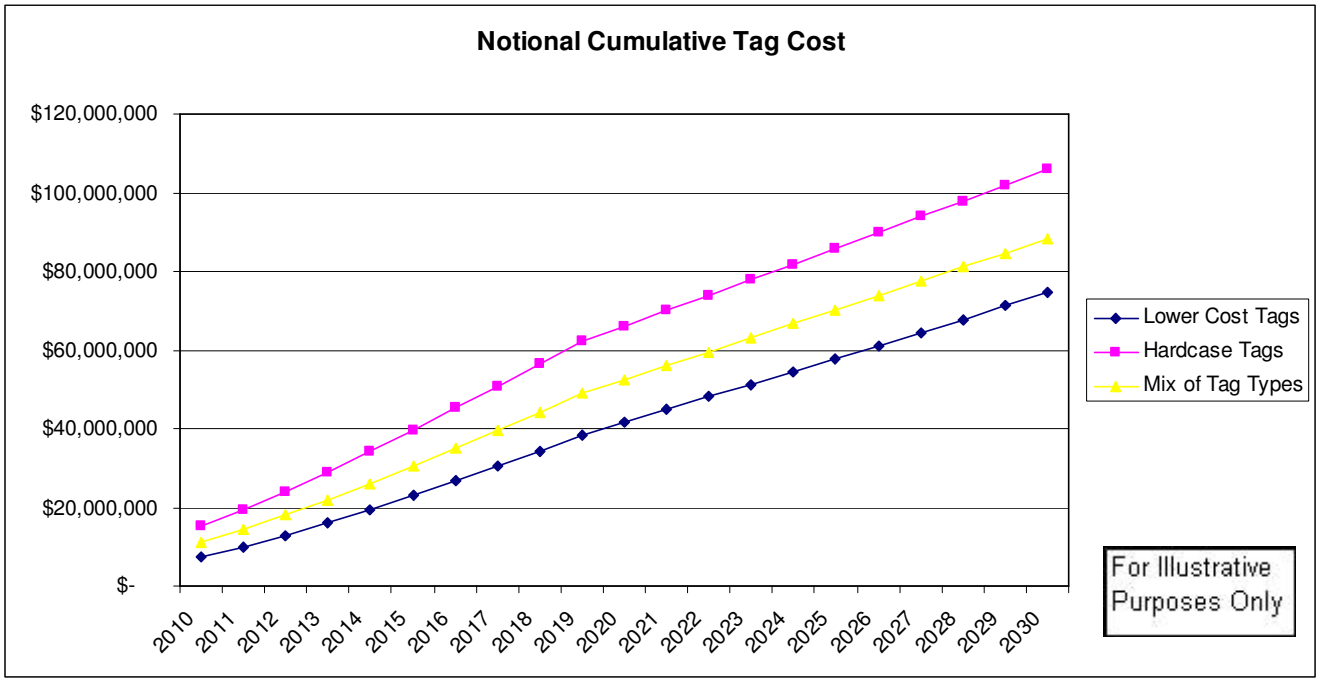
The choice of form factor is another consideration. The requirement to allow a driver to declare the number of occupants in the vehicle will require a hard case tag. The mode for 53% of vehicle trips are single occupant only trips. The remainder is HOV2+. Accordingly, not everyone will require a hard case transponder. But because everyone will pay a toll on SR 520, more vehicles require tags, unlike the current situation on SR 167 HOT lanes where only those who pay are required to have a tag. The implication is that a mix of tags with and without HOV self declare capability will be required.

TRANSPONDER COST CONSIDERATIONS

The unit costs for transponders vary from a sticker tag for around $10 per unit to the new 5.9 GHz tags at under $100 per unit. There is a higher cost for higher performance and newer technology. The driving factor for total transponder costs is based on the estimated number of accounts that will be established and the number of associated transponders plus accounting for the split of tags with and without HOV self declare capability.

The cumulative cost of transponders will be significant, starting with the initial surge in use and the annual increases due to increased participation, replacement transponders, and regional growth. An illustrative example of the potential cumulative cost is shown in the chart below. The chart

assumes that lower cost tags with limted functionality cost $10 per unit and hard case tags with HOV self declare functionality are $25 per unit. The notional analysis starts with an initial demand for approximately 700,000 tags and makes various assumptions for growth in the tolling program and replacement of tags over time. The mixed tag scenario assumes that 47% of the tags have HOV self declare capability. More detailed cost estimates will be developed in the future, but the analysis illustrates that a mixed tag approach is less expensive than hard case only approach and that getting the best price per unit has significant overall programmatic implications even if the public buys their own tags.



7. TRANSPONDER OPTIONS

The anticipated expansion of HOT lane program to other facilities dictates the need to have a transponder that is capable of allowing the drivers to self declare the number of persons traveling in their vehicle. This function cannot be provided in a lower cost tag. A hard case tag with buttons and driver feedback is required. However, some drivers will not take advantage of HOV discounts and may prefer a lower cost tag because of its reduced cost. In deciding on the purchase of tags in the future, a mix of lower cost tags and hard case tags with HOV self declare capability should be considered.